

Non-radial pulsations in the Be/X binaries 4U 0115+63 and SAX J2103.5+4545

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Abstract. The discovery of non-radial pulsations (NRP) in the Be/X binaries of the Magellanic Clouds (MC, eg. Fabrycky 2005, Coe *et al.* 2005, Schmidtke & Cowley 2005) provided a new approach to understand these complex systems, and, at the same time, favoured the synergy between two different fields: stellar pulsations and X-ray binaries. This breakthrough was possible thanks to the MACHO and OGLE surveys. However, in our Galaxy, only two Be/X have been reported to show NRP: GRO J2058+42 (Kiziloglu *et al.* 2007) and LSI+61 235 (Sarty *et al.* 2009). Our objective is to study the short-term variability of Galactic Be/X binaries, compare them to the Be/X of the MC and to the isolated Galactic Be observed with COROT and KEPLER. We present preliminary results of two Be/X stars, namely 4U 0115+63 and SAX J2103.5+4545 showing multiperiodicity and periodicity respectively, most probably produced by non-radial pulsations.

Keywords. stars: oscillations (including pulsations), stars: emission-line, Be, X-rays: binaries, stars: individual (4U0115+63, SAXJ2103.5+4545)

1. Introduction

Be/X-ray binaries consist of a neutron star orbiting a Be star. The early-type companion is believed to have the same physical properties as an isolated Be star. However, the structure and evolution of the equatorial disk is affected by the presence of the compact companion Reig (2007). While there are numerous detections of NRP in isolated Galactic Be stars, especially after the launch of the COROT mission (Gutiérrez-Soto *et al.* 2010), very little work on the search of variability associated with NRP in Galactic BeX exists. NRP can manifest themselves through multi-period photometric variability by modulating the stellar surface temperature. Typical periods associated with NRP in these stars range from few hours to 2 days.

We have set up a project to investigate the short-term optical photometric variability of BeX in the Milky Way. The main goal of this project is to detect NRP and compare their frequencies and amplitudes with those of isolated Galactic Be stars and with BeX in other galaxies with different metallicity content.

The Galactic Be/X studied in this project are 4U 0115+63, SAX J2103.5+4545, AO 0535+26 and 4U 2206+54. In this paper we only show the results for the two first targets.

Optical differential CCD-photometry was obtained in 3 sites in two observing campaigns between 2008 and 2009. We used the 1.3m telescope at the Skinakas observatory

(Crete), the 0.84 m telescope at the OAN (San Pedro Martir, Mexico) and the 1.5 m telescope at the Observatorio de Sierra Nevada (OSN) located in Granada, Spain. A total of 945 datapoints in 29 nights and 497 datapoints in 22 nights were collected for the stars 4U 0115+63 and SAX J2103.5+4545 respectively. The data were obtained primarily in the Johnson V.

2. Results

The target 4U 0115+63 showed variations in 2008, with a frequency of $3.3 d^{-1}$ and an amplitude of 18 mmag. In 2009, 2 significant frequencies at 3.33 and $1.60 d^{-1}$, with amplitudes of 14 mmag and 7 mmag respectively were detected in the Skinakas data. As seen in the Be stars observed with the COROT mission (eg. Gutiérrez-Soto *et al.* 2009), the relationship between the two largest frequencies is very close to 2:1. The main frequency $3.33 d^{-1}$ is too high to be the rotational frequency. If we assume that the frequency $1.60 d^{-1}$ is the rotational frequency, the Be star should rotate at critical velocity. Therefore, these variations are most probable due to NRP.

A frequency at $2.23 d^{-1}$ with an amplitude of 4 mmag was found in the light curve of SAX J2103.5+4545. Using the radius and mass of a star with spectral type B0 derived by Vacca *et al.* (1996), and assuming that the star is rotating at break-up velocity, we calculate a rotational frequency of $1.6 d^{-1}$. Therefore, the frequency $2.23 d^{-1}$ is attributed to non-radial pulsations.

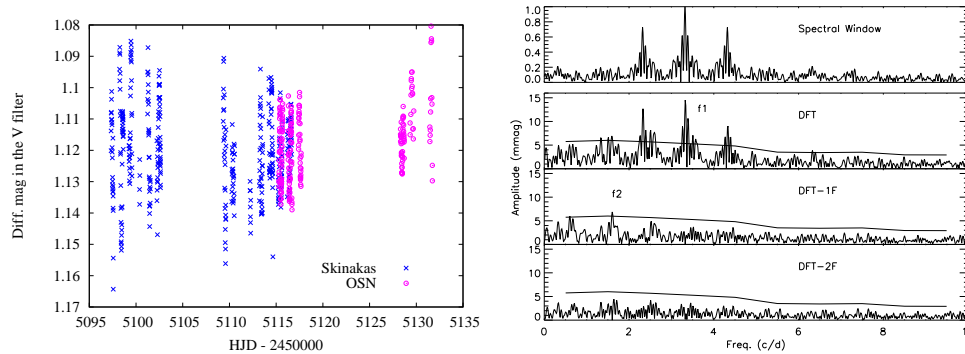


Figure 1. Left: The Skinakas (blue crosses) and the OSN data (purple circles) for the star 4U 0115+63. Right: The subsequent periodograms of the Skinakas data for the star 4U 0115+63. The horizontal line represents the 3.5 signal-to-noise level

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